Full Field Processing (FFP) Program

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LONG TERM GOALS

Our long term goal is to quantify via measurement, the advantage of three dimensional arrays for detection, tracking and classification of surface ships and submarines and to extrapolate these results to other environments and conditions. This is to be accomplished using adaptive full field methods using narrowband and broadband array processing, followed by tracking algorithms which are similar to the maximum likelihood method contrained by certain track considerations.

OBJECTIVES

More specifically, our objectives are to measure and understand the range-frequency limits of full field processing and the gain that can be achieved against wind and shipping noise in a dynamic environment and compare those results to that obtained with a horizontal line array. As part of this analysis we seek to compare the performance of the FFP array with a horizontal line array (HLA) in terms of signal, noise and array gains. In addition to the results cited above which a based on CW measurements, we seek to determine how broadband frequency combination and tracking can improve detection performance and classification.

APPROACH

We planned & conducted two experiments in the Santa Barbara Channel area, the first in April of 1998 and the second in May of 1998. This is a highly dynamic noise environment averaging one ship per hour through the channel and highly variable wind speeds. The test was conducted using a source towed from the Acoustic Explorer, and the natural and augmented signatures of other U.S. Navy assets. In addition, a number of CTD measurements were made in the experiment area using a smaller commercial vessel during the first of two tests (SBCX I). Supporting radar measurements from the NAS Point Mugu were obtained during the course of both tests. The tests were supported by numerous organizations including SAIC, Orincon, DARPA, NRAD, MPL, & NAS Pt. Mugu. Two arrays were deployed, the five vertical line array FFP array and a horizontal line array. The FFP array was cabled back to a laboratory site at Pt. Mugu using standard telephone fiber optic cable and SONET/ATM technology. Data were recorded on 35 Gbyte DLT tapes. The HLA was deployed from FLIP.

WORK COMPLETED

During the past year SAIC along with other organizations, principally MIT Lincoln Labs, MIT, and Orincon, have been analyzing acoustic data from various time periods in the experiment. In addition

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1999		**00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Full Field Processing (FFP) Program	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Science Applications International Corporation (SAIC),Marine Technology Division,1710 Goodridge Drive,McLean,VA,22102**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**3**	

SAIC has prepared data sets for analysis by others including quality checks, shape files for the FFP array, and miscellaneous supporting data sets. In addition, we have performed a statistical analysis of the environmental data that supports the analysis and understanding of signal mismatch.

The analysis of the acoustic data has focused on mismatch calculations for a number of frequencies and propagation distances out to 15 kilometers from the FFP array. The emphasis has been on using one array with more recent work using multiple VLA's. In addition, we have calculated noise gains for a number of data sets as well as doing a detection analysis for the naturally radiated target signatures.

We are also in the process of comparing the performance of the FFP and HLA on the basis of SNR's for identical time periods. This will allow an assessment of the utility of vertical aperture.

Another area of investigation that started late last fiscal year relates to frequency combination and tracking for broadband signals. Although the initial investigations utilized the CW tonals from the towed source and the naturally radiating tonals from the submarines, we are currently utilizing the natural broadband signatures of the Acoustic Explorer and the other navy assets.

Lastly, as stated in our Environmental Assessment, in March of 1999 we removed the FFP array and the trunk cable. The trunk cable itself was damaged sometime between July of 1998 and September 1998. In addition, when the array was recovered it was found that two of the VLA's were severely damaged.

RESULTS

Analysis of the CW transmissions from the towed source and the augmentation signals from Dolphin indicate that single VLA's can be successfully focused at ranges of less than 8 km at frequencies of less than 300 Hz. This result is obtained with a baseline environment that used a high resolution bathymetric data base, sediment properties near the water sediment interface at the array site, and a single sound speed profile which was obtained from the average of all CTD measurements in the experiment area. We are now in the process of extending the range beyond 8 km using more refined environmental definitions.

We have also demonstrated significant noise gains when ships were in the experiment area using a number of adaptive beamforming techniques. These techniques have included white noise constrained, reduced rank, and mode space methods. These methods have demonstrated detections of low-level CW signals out to operationally interesting distances under fairly noisy conditions.

Lastly, we are now in the process of attempting to exploit the broadband nature of all signatures using frequency averaging and tracking. This processing will attempt to focus all five VLA's on the target to optimize the detection statistic. As part of this process, we are also developing methods that exploit a priori knowledge about the location of surface ships for noise suppression.

IMPACT/IMPLICATION

We have shown that single VLA's localized using engineering sensors can be focused out to 8 km at several hundred Hertz. This has been done using CW signals as well as broadband signals. The environmental information needed to accomplish this is an average SVP, average sediment properties,

but a fairly detailed bathymetric description. Noise gains using single VLA's and robust adaptive methods have been shown to produce significant array gains against surface shipping.

TRANSITIONS

No current transitions

RELATED PROJECTS

The follwing is a list of related projects:

Matched-Field processing Classification (ONR321US)
Environmentally Enhanced Signal Processing (ONR/NRL)
Shallow Water Ambient Noise (ONR/NRL)
Full Spectrum Processing (ONR321US)
Covert Calibration of deployable Arrays (ONR321US)
Ocean Measurements and Modeling (ONR322OM)
Situationally Adaptive Sonar technologies (DARPA/TTO)
USS Dolphin Project (PMS395)
SSC-SD Naval reserve Unit 119 (Code 03R)

REFERENCES

none

PUBLICATIONS

ASAP99 – Papers presented by SAIC, MIT/LL, and Orincon
Oceans 99 – Papers presented by MIT/LL